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ABSTRACT

The Institute for the Advancement of Emerging Technologies in Education (IAETE) at AEL recently explored the potential benefits and limitations of traditional print-based textbooks and many e-book alternatives. Having considered these media, IAETE created prototype interactive textbook pages that retain the salient aspects of print media while providing access to unlimited electronic resources. While the prototype appears to be a standard textbook, imperceptible digital watermarks embedded in the graphics act as convenient conduits to electronic access of dynamic content, assessments, applications, and communication tools. IAETE is exploring digital watermarking as an alternative to delivering electronic instructional media. This report covers the following topics: (1) traditional textbooks; (2) electronic books (e-books); (3) issues influencing e-book development; (4) alternatives for electronic publishing of textbooks, including handheld devices, customized printing, and Web-based delivery; (5) the interactive textbook; and usability study and group interview results. PowerPoint print-outs from a presentation on digital watermarking are attached. (Contains 21 references.) (MES)

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Using Imperceptible Digital Water
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address the inherent limitations of print media, the application and implications of imperceptible digital watermarking technologies were considered in the context of learning environments. Prototype textbook pages were developed using Digimarc MediaBridge software and a widely used middle school science textbook.

The software creates an imperceptible digital watermark consisting of XML-based code embedded in a graphic or other media element. With the aid of an optical reader device, such as a digital camera connected to a computer, the software "reads" the watermark, activates a standard Web browser, and delivers the user to a specified Web site or application. The interactive textbook extends the functionality of print media so that applications now possible on the Web, including discussions with peers or experts, real-time data manipulation, and participation in simulations or virtual environments, are possible within the context of the interactive book.

Static information, such as the definition of a term, is presented in a common textbook format and organizational structure, but information likely to change, such as an assessment tool, is linked to the printed page with an imperceptible digital watermark. The digital watermark feature makes the content highly customizable. Unique identifiers embedded in each image enable a content manager to access or change the referent URL to provide a relevant and timely experience for the user without requiring any change to the printed book.

Embedding a watermark in an image is as easy as applying a filter in Photoshop. The process for transforming a printed textbook into an electronic textbook does not displace well-established textbook production methods and utilizes standard image processing software. It is already adopted by print media and could be easily integrated by the textbook publishing industry.

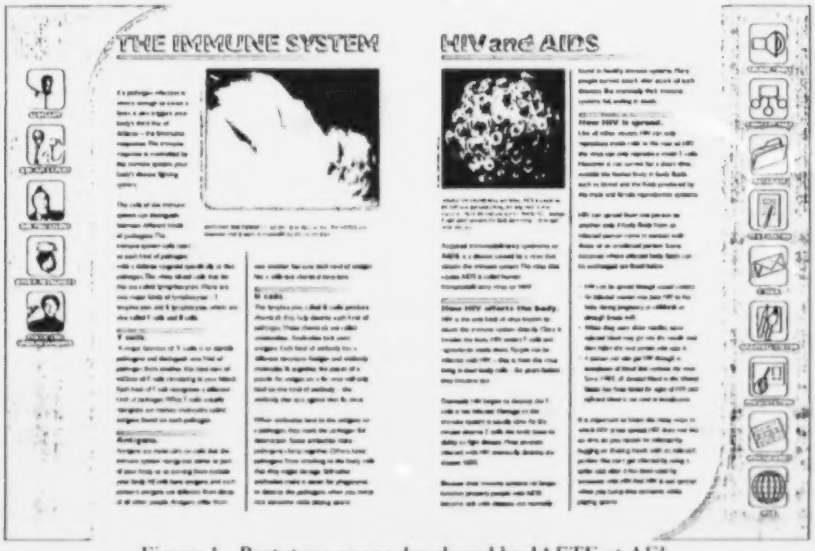

Figure 1. Prototype pages developed by IAETE at AEL

Prototype pages are presented in Figure 1. An imperceptible digital watermark is embedded in each graphic, delivering users to a specified Web site or application. The resource bar on the left contains five resource links:

1. *Glossary* links users to definitions of terms related to the subject content and can be chapter- or even page-specific.

2. *Ask an Expert* links users to experts who can answer student-generated questions. The expert could be identified by the textbook company or by the teacher, allowing international, national, local, or school-based authorities to share information.

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3. *Did You Know* provides a connection to materials designed for differentiated instruction. Students who progress quickly through their work could explore many layers of supplemental content through this link. The activities could be high-interest and require varied skill levels.

4. *Other Resources* presents supplemental, content-related materials, information, and activities.

5. *Check for Understanding* offers opportunities to assess student comprehension through traditional assessments or problem-based assignments.

The tool bar on the right displays nine icons linked to different tools (i.e., Sound Tools, Concept Map, Database, Text Editor, E-mail, Graphics Editor, Presentation, Spreadsheet, and Web). Each icon provides a shortcut to a designated application, giving students instant access through the watermark in the textbook.

The illustrations on the page are also digitally watermarked and serve as a point of departure for activities related to the text. In Figure 1, the digital watermark in the "Mystery Bacteria?" (ear) illustration delivers students to an online virtual lab simulation where they attempt to identify the pictured bacteria. Other possibilities for links include labeled diagrams, enhancements of photographs or maps, and questions related to the illustration.

The adaptive nature of the technology holds promise for highly customizable content in multiple curricular areas. Differentiated instruction is supported by enabling students to "drill down" in content. Real-time, embedded assessments are supported, as is the ability to follow a student's path through the content. Sound tools, concept mapping, and other applications engage students and enable them to interact with the content in whatever way is most appropriate for them. Although the examples above were used in the prototype, different tools and resources could easily be used to support other content areas.

Usability Study and Group Interview

Following the development of the prototype, IAETE conducted a usability study, then a small group interview. Participants included middle school and high school science teachers. The usability study was conducted prior to the focus group to elicit unbiased results. The participants were given five assignments, without instruction, which required participants to access multiple resources and tools. They worked as a group, and a talk-aloud protocol was used. Following the usability study, the group discussed the prototype and identified five key benefits: (1) the availability of real-time information, (2) more efficient computer use, (3) accommodation of multiple modes of learning, (4) standards-based content, and (5) the availability of assistive resources. Four limitations were noted: (1) access to computing device, (2) cost, (3) durability, and (4) the need for additional workspace.

The teachers rated the interface design and the ease of operation of the interactive textbook using a five-point scale, where 1 was the most negative response and 5 was the most positive response. The mean response for interface design was 4.75, and the mean response for ease of operation was 3.5.

During group discussion, the tool bar was the subject of much debate. Some teachers thought it was unnecessary, while others argued that the shortcuts would be helpful for keeping students on task. The teachers brainstormed about the possible layout (e.g., putting the tool bar on the back cover) and potential functions (e.g., using the sound tool to assist ESL students). IAETE will use the results of this study to refine the prototype and prepare for a larger usability study that will include teachers and students.

Summary

At present, e-books appear to be supplementing print media, not replacing them (Ditlea, 2000). This suggests that print-based textbooks are likely to be prevalent in classrooms for some time. This prototype concept, using imperceptible digital watermark technology, demonstrates a realistic and practical method for linking print and digital media. It is likely that the limitations identified through the usability study and focused group interview can easily be addressed as handheld computing devices become more commonplace in classrooms and more suitable optical reader devices become available.

Imagine it—a smaller textbook accompanied by a small, wireless, tablet-like computer and reader device/stylus that is no bigger than a permanent marker. The interactive textbook is a viable model affording students the best aspects of print and electronic media.

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Using Imperceptible Digital Watermarking to Transform Educational Media

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AECT ★ November 14, 2002

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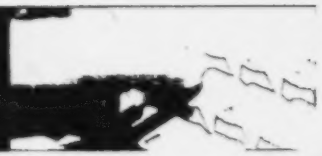
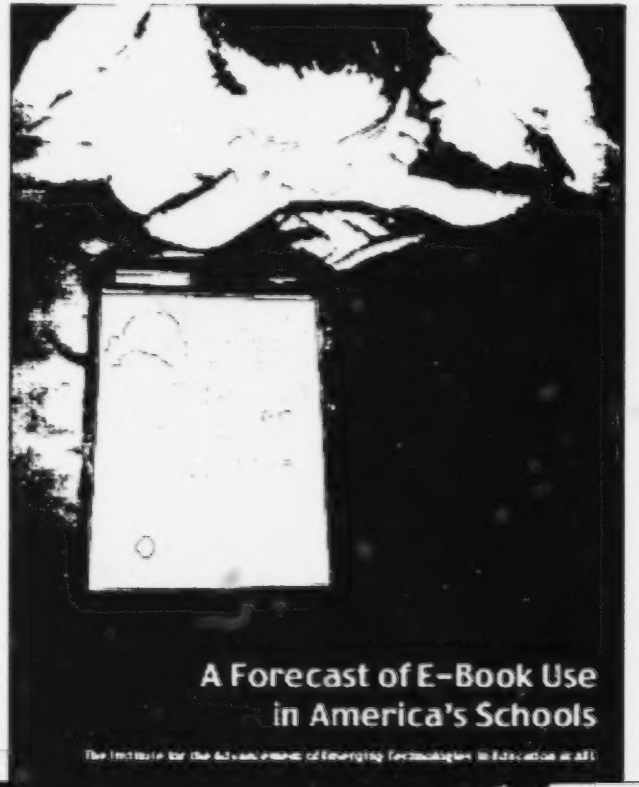
Textbooks

- The dominant form of instructional media
- Development is driven by market demand
- Content can become outdated quickly
- Often criticized for being ill-suited to curriculum and assessments
- Plagued with errors (Hubisz, 2001; Roseman, Kesidou, Stern, & Caldwell, 1999)



A Forecast of E-Book Use in America's Schools

- Survey of textbook adoption staff
  - 22 States & 100 largest school districts
- Highlights
  - Selection policies
  - Frequency of adoption
  - Satisfaction
  - E-book possibilities



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What is an E-Book?

- **E-book**: small electronic device on which e-text may be loaded
- **E-text**: written material delivered digitally on e-book or computer
- **E-textbook**: electronic media pre-selected for instruction and displayed on e-book

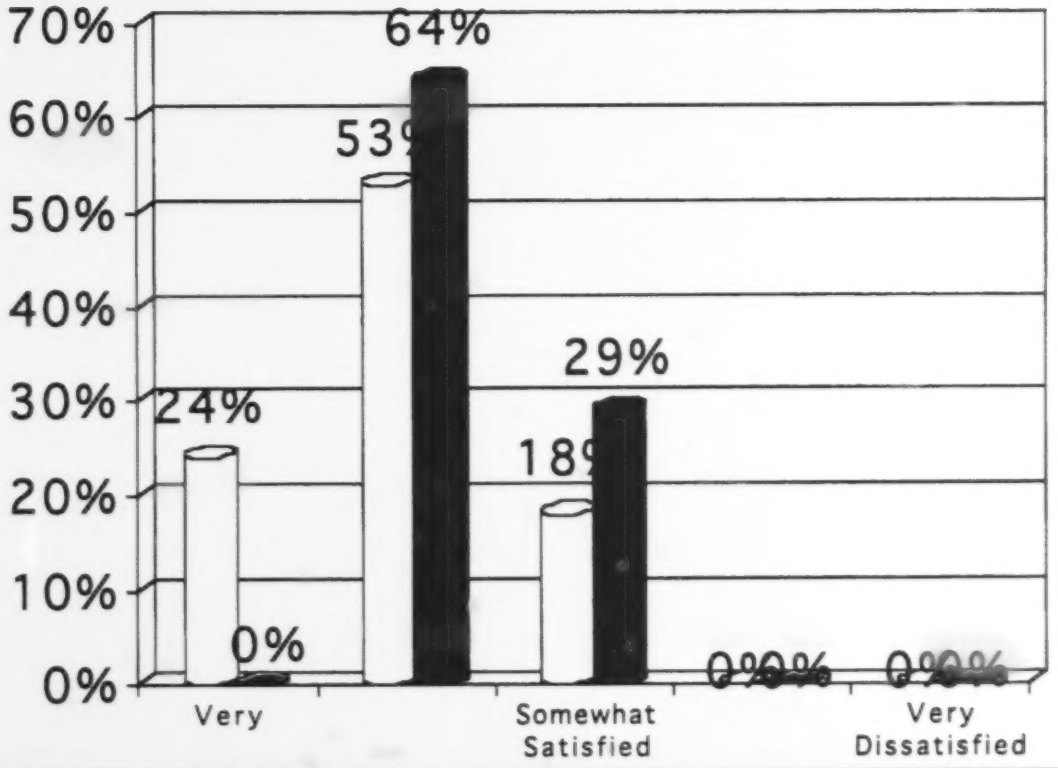
Most Important Selection Priorities

STATES	DISTRICTS
Match standards	Match standards
Accuracy	Accuracy
Currency	Currency
Recommended activities	Organization
Organization	Recommended activities

Least Important Selection Priorities

STATES	DISTRICTS
Cost	Cost
Supplemental electronic media	Supplemental electronic media
Visual presentation	Publishing company
Publishing company	Visual presentation
Noted authors	Noted authors

Satisfaction



Perceived Strengths of Current Textbooks

States

- Accuracy (94%)
- Match standards & assessments (82%)
- Currency of information (76%)

Districts

- Match standards & assessments (7%)
- Meet students' needs (64%)

Perceived Weaknes of Current Textbook

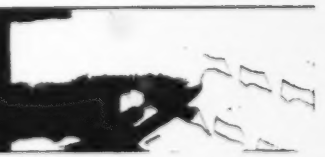
States	Districts
• Too heavy to carry (77%)	• Too heavy to ca (71%) • Outdated (50%)

Current Practice

- Adoption cycles: 4 to 7 years
- The most common procedure for adopt textbooks is allowing districts to select state-approved list.
- None of the states responding requires districts to adopt a print-based textbool

Current Practices

- Science and reading are the most difficult areas in which to find appropriate textbook selections.
- There was little agreement about the instructional level for which it is most difficult to make appropriate book selections.
- Respondents indicated that print-based textbooks are important or very important in their instructional programs.



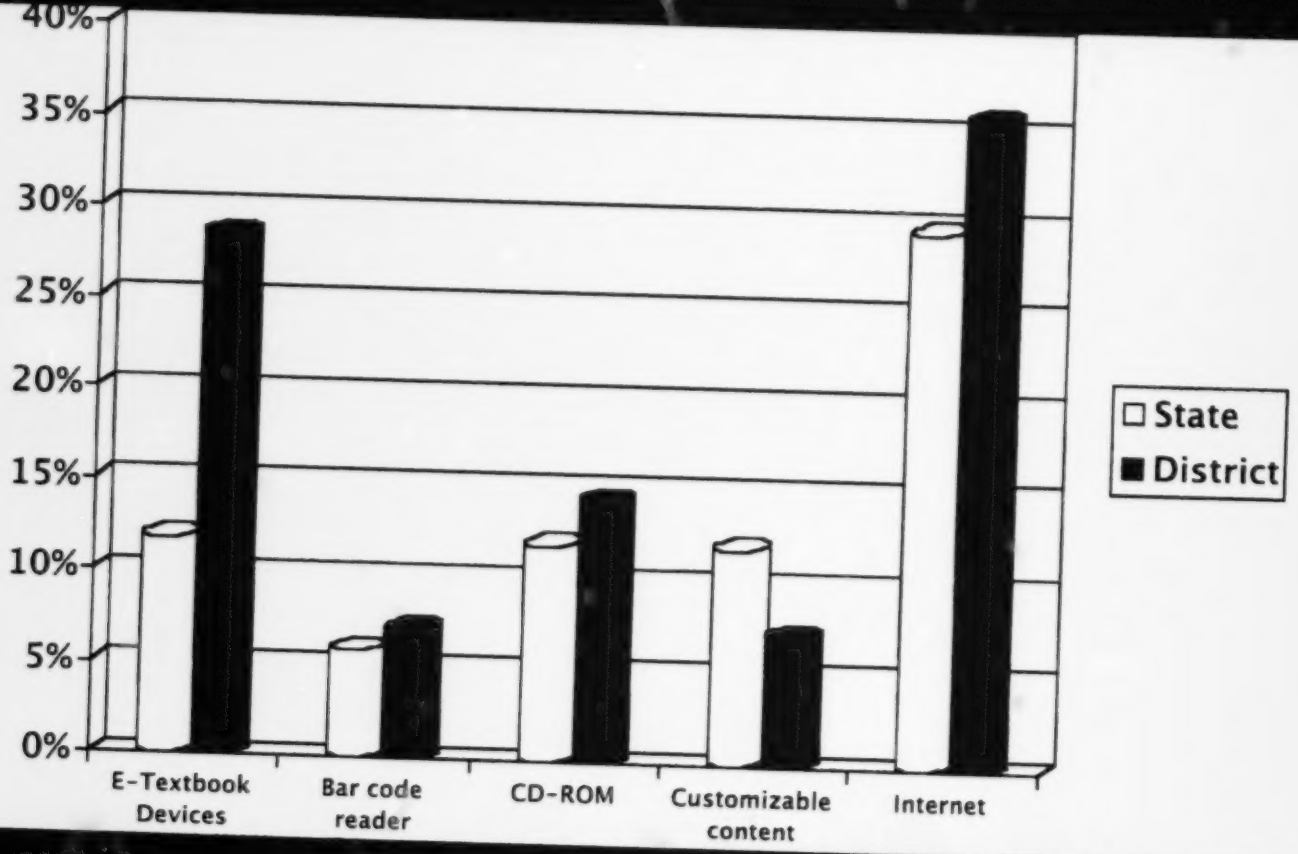
Perceived Benefits and Barriers of Electronic Media

- **Greatest benefit:** Information remains current
  - Greater control over content
- **Greatest barrier:** Access for all students

The Internet is perceived to be most likely choice of electronic media delivery

There is little interest in using e-books

Predicting Electronic Devices



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The Web as a Textbook Replacement

- Individuals read 25% more slowly from a screen (Nielson, 2000)
- Novice users are often impeded by cumbersome interface
- Information overload

Is It Time to Abandon the Textbook?

"We have had 500 years experience using printed textbooks and they not only support a wide range of applications, but users also have such a strong mental model of their generic structure and organization that they can successfully adopt an equally wide range of usage strategies."

(McKnight, Dillon, and Richardson, 1996)

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be

instantly
respond to requests for more information

What if Textbooks could...

change
the way students and teachers use the Internet

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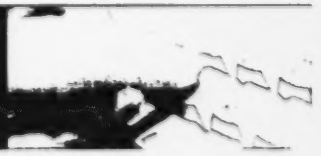
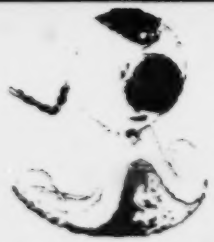


Digital Watermarking

- Digital code in printed material
- Inconspicuous to readers
- "Readable" by consumer PC cameras and scanners
- Instantly sends readers to specified Internet destination
- Turns every printed item into a direct Internet portal
- Can instantly launch applications from a hard drive

Connecting Print to the Web



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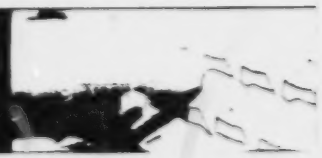

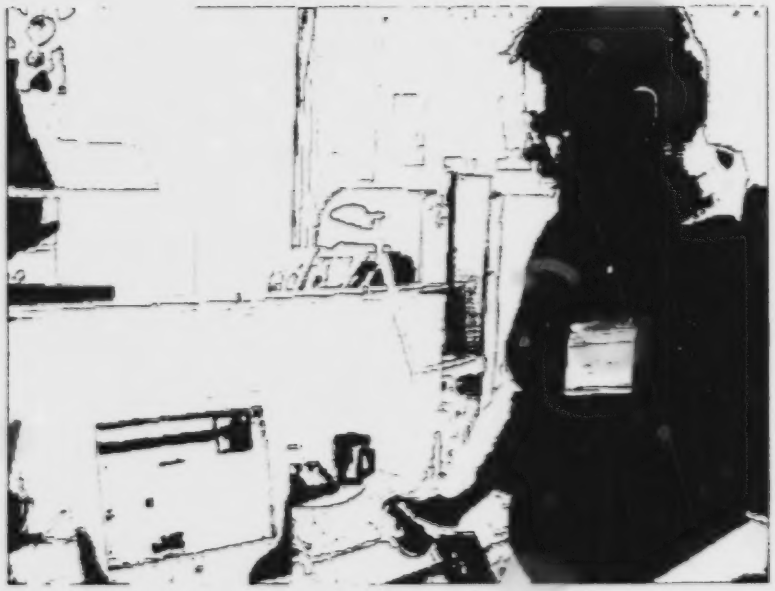

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THE IMMUNE SYSTEM

If a pathogen infection is severe enough to cause a fever, it also triggers your body's third line of defense – the **immune response**. The immune response is controlled by the immune system, your body's disease fighting system.

MYSTERY BACTERIA! Even the kit is shown! Can you tell how to determine what bacteria is responsible for the this condition.

The cells of the immune system can distinguish between different kinds of pathogens. The immune-system cells react to each kind of pathogen with a defense targeted specifically at that pathogen. The white blood cells that do this are called **lymphocytes**. There are two major kinds of lymphocytes – T lymphocytes and B lymphocytes, which are also called T cells and B cells.

T cells.

A major function of **T cells** is to identify pathogens and distinguish one kind of pathogen from another. You have tens of millions of T cells circulating in your blood. Each kind of T cell recognizes a different kind of pathogen. What T cells actually recognize are marker molecules, called antigens, found on each pathogen.

Antigens.

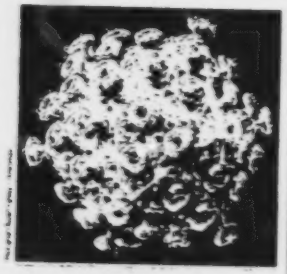
Antigens are molecules on cells that the immune system recognizes either as part of your body or as coming from outside your body. All cells have antigens, and each person's antigens are different from those of all other people. Antigens differ from one another because each kind of antigen has a different chemical structure.

B cells.

The lymphocytes called **B cells** produce chemicals that help destroy each kind of pathogen. These chemicals are called **antibodies**. Antibodies lock onto antigens. Each kind of antibody has a different structure. Antigen and antibody molecules fit together, like pieces of a puzzle. An antigen on a flu virus will only bind to one kind of antibody – the antibody that acts against that flu virus.

When antibodies bind to the antigens on a pathogen, they mark the pathogen for destruction. Some antibodies make pathogens clump together. Others keep pathogens from attaching to the body cells that they might damage. Still other antibodies make it easier for phagocytes to destroy the pathogens. When you bump into someone while playing sports.

HIV and AIDS



Acquired immunodeficiency syndrome, AIDS is caused by the HIV virus (pictured above), the only kind of virus known to attack the immune system directly. AIDS destroys T cells, which prevents the body from being able to fight other diseases.

Acquired immunodeficiency syndrome, or **AIDS**, is a disease caused by a virus that attacks the immune system. The virus that causes AIDS is called human immunodeficiency virus, or **HIV**.

How HIV affects the body.

HIV is the only kind of virus known to attack the immune system directly. Once it invades the body, HIV enters T cells and reproduces inside them. People can be infected with HIV – that is, have the virus living in their body cells – for years before they become sick.

Eventually HIV begins to destroy the T cells it has infected. Damage to the immune system is usually slow. As the viruses destroy T cells, the body loses its ability to fight disease. Most persons infected with HIV eventually develop the disease AIDS.

Because their immune systems no longer function properly, people with AIDS become sick with diseases not normally found in healthy immune systems. Many people survive attack after attack of such diseases. But eventually their immune systems fail, ending in death.

How HIV is spread.

Like all other viruses, HIV can only reproduce inside cells. In the case of HIV, the virus can only reproduce inside T cells. However, it can survive for a short time outside the human body in body fluids, such as blood and the fluids produced by the male and female reproductive systems.

HIV can spread from one person to another only if body fluids from an infected person come in contact with those of an uninfected person. Some instances where infected body fluids can be exchanged are listed below.

- *HIV can be spread through sexual contact.*
- *An infected woman may pass HIV to her baby during pregnancy or childbirth or through breast milk.*
- *When drug users share needles, some infected blood may get into the needle and then infect the next person who uses it.*
- *A person can also get HIV through a transfusion of blood that contains the virus. Since 1985, all donated blood in the United States has been tested for signs of HIV, and infected blood is not used in transfusions.*

It is important to know the many ways in which HIV is not spread. HIV does not live on skin, so you cannot be infected by hugging or shaking hands with an infected person. You can't get infected by using a toilet seat after it has been used by someone with HIV. And HIV is not spread when you bump into someone while playing sports.

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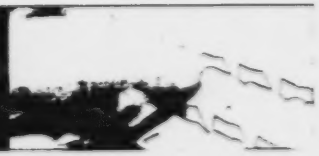
Interactive Textbook

- Capitalizes on well-established textbook production methods
- Retains the most salient aspects of print media while providing instant and convenient access to
  - dynamic content
  - assessments
  - applications
  - communications tools
- Images do not differ in appearance from those found in traditional printed textbooks

Focus Group Interview and Usability Study

- Talk aloud method
- Middle and high school science teachers
- Appeal of the interface (75% “excellent”; 25% “good”)
- Ease of operation (75% “fair”; 25% “excellent”)
- Real-time information a key benefit
- Computer access issues a key concern



Next Steps

- Develop or identify enhanced reader device
- Develop assessment and reporting components

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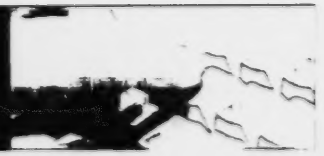

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